Topics in Bank Management: Lecture 2

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What Can Banks Do That Investors Can't Do By Themselves?

- Last week, we saw that in a general equilibrium with complete markets (i.e. a security exists for every possible state of the world), there is no role for banks.
- If consumers can directly lend to borrowers, or buy and trade securities, then there is no need for a financial intermediary.
- If we want to model financial intermediaries correctly, we need to specify something that individual consumers cannot do by themselves.
- This week, we'll look at three models that provide this rationale:
    - A single depositor cannot diversify against liquidity shocks, but a coalition of many depositors can;
    - If there is asymmetric information between borrowers and lenders, a coalition of lenders can decrease the cost of capital;
    - If lenders have to monitor borrowers, then a financial intermediary that deals with many lenders can decrease the average cost of monitoring.

Coalitions of Depositors (Ch. 2.2)

- One way to think about depository institutions like banks: *pools of liquid assets* (e.g. cash).
- Individual households need cash due to idiosyncratic shocks (e.g. to finance consumption).
- These households can combine their resources in a coalition, to diversify against risk.
- As long as these households' shocks are not correlated across time, then the total cash reserve needed to satisfy these shocks increases less slowly than the total number of households.

The Model

- There are three time periods: $t = 0, 1, 2$.
- There is 1 good.
- A continuum of consumers who are identical at $t = 0$ are endowed with 1 unit of the good.
- At $t = 1$, the consumers learn what type they are.
  - Type-1 consumers are called "early" consumers, and consume only in $t = 1$, with utility $u(c_1)$
  - Type-2 consumers are called "late" consumers, and consume only in $t = 2$, with utility $u(c_2)$
- Let π_1, π_2 be the probability of being Type-1 or 2. The expected utility at $t = 0$ is

$$U = \pi_1 u(c_1) + \pi_2 u(c_2)$$

The Model

- At $t = 0$, a consumer can choose to consume his endowment, or save it in two ways:
  - Store it for 1 period. This is equivalent to a riskless asset with a net return of 1.
  - Invest amount I in a long-run technology, which gives a net return of $R > 1$ at $t = 2$, but it can be *liquidated* early, to give a return of $L < 1$ in $t = 1$.
- For example, a long-dated certificate of deposit, or a long-term construction project.

Optimal Allocation

- First, let's look at the optimal allocation, which maximizes expected utility at $t = 0$.

$$\max_{c_1, c_2, I} \pi_1 u(c_1) + \pi_2 u(c_2) \qquad \text{subject to}$$

$$\pi_1 c_1 = 1 - I, \pi_2 c_2 = RI \Rightarrow \pi_1 c_1 + \pi_2 \frac{c_2}{R} = 1$$

- The first order condition is

$$u'(c_1^*) = Ru'(c_2^*)$$

- The marginal rate of substitution between consumption at $t = 1, 2$ equals the return on the long-run technology.

Autarky: No Trade Between Agents

- Suppose that trade between agents is not allowed.
- At $t = 0$, each agent chooses the amount to store, and the amount to invest I.
- Then at $t = 1$, their type is revealed.
  - Type-1 agents' income will be the amount they stored, plus LI (the liquidation value of what was invested in $t = 0$)

$$c_1 = 1 - I + LI = 1 - I(1 - l)$$

  - Type-2 agents' will continue their storage until $t = 2$. Then, their income will be the amount they stored, plus RI (the long-term return on what was invested in $t = 0$)

$$c_2 = 1 - I + RI = 1 + I(R - 1)$$

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- At $t = 0$, all investors will maximize expected utility subject to these two constraints.
- Note that $c_1 \leq 1$, with equality if $I = 0$.
- $c_2 \leq R$, with equality if $I = 1$.

Autarky: No Trade Between Agents

- Note that $c_1 \leq 1$, with equality if $I = 0$.
- $c_2 \leq R$, with equality if $I = 1$. Since both cannot hold, then

$$\pi_1 c_1 + \pi_2 \frac{c_2}{R} < 1$$

- This is inefficient, since some resources are lost due to early liquidation.

Introduce a Financial Market for Bonds

- Suppose that agents are allowed to trade a riskless bond with other agents.
- We model this by introducing a financial market at $t = 1$: agents can trade 1 unit of the good for 1 riskless bond that has price p (endogenously determined), and returns 1 at $t = 2$.
- We will assume agents are price-takers.
- Since this is after agents' types have been revealed, Type 1 agents will trade with Type 2 agents.
- Both Type 1 and Type 2 agents chose the same amount of I, since their type was not yet revealed.

Introduce a Financial Market for Bonds

- Both Type 1 and Type 2 agents chose the same amount of I, since their type was not yet revealed.
- Type 1 agents will sell bonds at $t = 1$. They will repay these bonds at $t = 2$ with the returns of the long-term technology:

$$c_1 = 1 - I + pRI$$

- Type 2 agents will buy bonds at $t = 1$ with the amount they stored, and get extra consumption at $t = 2$:

$$c_2 = \frac{1 - I}{p} + RI = \frac{1}{p}(1 - I + pRI)$$

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Introduce a Financial Market for Bonds

$$c_1 = 1 - I + pRI$$

$$c_2 = \frac{1-I}{p} + RI = \frac{1}{p}(1 - I + pRI)$$

- Note that c_1 and c_2 are linear functions of I, and $c_2 = \frac{c_1}{p}$.
- The only interior equilibrium occurs when $p = \frac{1}{R}$.
- If $p > \frac{1}{R}$, then $I = 1$ and there is an excess supply of bonds: Type-1 agents will sell bonds, but no one will buy them
- If $p < \frac{1}{R}$, then $I = 0$ and there is excess demand of bonds: Type-2 agents want to buy bonds, but no one will sell them

Introduce a Financial Market for Bonds

- At equilibrium, $c_1 = 1, c_2 = R, I = \pi_2$.
- This Pareto-dominates the autarky solution since there is no liquidiation, therefore no wasted resources.
- However, the first-order condition $u'(c_1^*) = Ru'(c_2^*)$ is not satisfied.
- Efficiency is acheived when there is *perfect insurance*: the marginal utility is equalized across all possible states of the world (that is, all possible random outcomes).
- In a complete market (i.e. there is a security corresponding to every outcome), risk-averse agents will perfectly insure.
- This market, however, is incomplete, since there is no security corresponding to the outcome of the liquidity shock (Type 1 vs. Type 2).

Financial Intermediation

- Suppose we know what the optimal allocation (c_1^*, c_2^*) is.
- Assume there is a financial intermediary that offers this *deposit contract*:
  - In exchange for 1 unit at $t = 0$, the FI will pay either c_1^* at $t = 1$, or c_2^* at $t = 2$.
- Out of the 1 deposited, the FI will store $\pi_1 c_1^*$, and invest $1 - \pi_1 c_1^*$ in the long-term technology.
- The FI achieves the Pareto-optimal allocation.
- Note that this requires that only Type-1 depositors withdraw at $t = 1$; this is true in Nash equilibrium, since Type-2 depositors would lower their payoff if they withdrew early.
- There is another Nash equilibrium where *all* Type-2 depositors withdraw; this is a bank run and will be studied later in the course.
- One problem with this model is that the FI cannot coexist with a financial market.

Adverse Selection

- Let's look at a simple model of adverse selection.
- Suppose Player 1 owns a car, and Player 2 is considering whether to buy the car from Player 1.
- The car has a level of quality α, which can take on three types, L, M, H.
- Player 1 knows the type of the car, but Player 2 does not.
- Player 1's valuation of the car is:

$$v_1(\alpha) = \begin{cases} 10 & \text{if } \alpha = L \\ 20 & \text{if } \alpha = M \\ 30 & \text{if } \alpha = H \end{cases}$$

- The higher the quality, the higher is Player 1's valuation of the car.

Adverse Selection

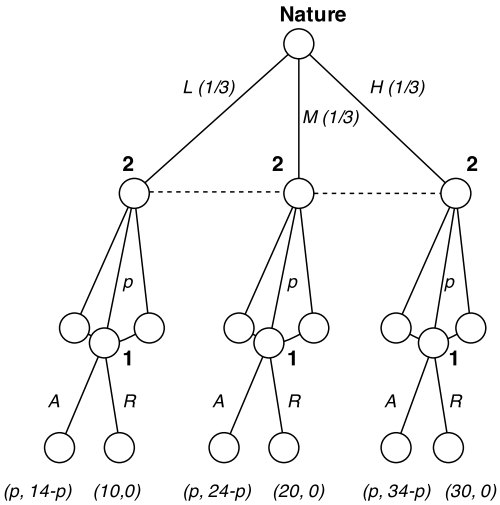
- Likewise, suppose that Player 2 has a similar valuation of the car:

$$v_2(\alpha) = \begin{cases} 14 & \text{if } \alpha = L \\ 24 & \text{if } \alpha = M \\ 34 & \text{if } \alpha = H \end{cases}$$

- Player 2 knows that the probability distribution of quality levels in the general population is $\frac{1}{3}$ for each type.
- Note that Player 2's valuation of the car is higher than Player 1's valuation, for all quality levels of the car.
- Therefore, if the type were common knowledge, a trade should occur: it is always possible to find a Pareto-efficient trade (that is, both players are not worse off, and at least one player is better off).
- For example, if it were known that quality was L, a trade at a price between 10 and 14 would make both players better off.

Adverse Selection

- Consider the following game:
  - Nature chooses the type of the car with $P(L) = P(M) = P(H) = \frac{1}{3}$. Player 1 observes the type; Player 2 does not.
  - Player 2 makes a price offer $p \geq 0$ to Player 1 for the car.
  - Player 1 can accept (A) or reject (R).
  - If Player 1 accepts, he gets the price offered, and the car is transferred to Player 2.
  - If trade occurs, Player 1's payoff is the price offered. Player 2's payoff is his valuation of the car, minus the price paid.
  - If trade does not occur, Player 1's payoff is his valuation of the car. Player 2's payoff is zero.


Nature
L (1/3)
M (1/3)
H (1/3)
2
2
2
p
p
p
1
1
1
A
R
A
R
A
R
(p, 14-p)
(10,0)
(p, 24-p)
(20, 0)
(p, 34-p)
(30, 0)

Adverse Selection

- Consider the subgame after p has been offered.
- Player 1's best response is:
  - If $\alpha = L$, accept if $p \geq 10$, reject otherwise.
  - If $\alpha = M$, accept if $p \geq 20$, reject otherwise.
  - If $\alpha = H$, accept if $p \geq 30$, reject otherwise.
- Now, consider Player 2's decision. His beliefs match Nature's probability distribution: the probability on L, M, H is $1/3$ each.
- Let's find the expected payoff $E_2(p)$ of choosing p, for the range $p \geq 0$.

Adverse Selection

- If $p < 10$, Player 1 will reject in all cases. $E_2(p) = 0$.
- If $10 \leq p \leq 14$, $E_2(p) = \frac{1}{3}(14 - p) + \frac{1}{3}(0) + \frac{1}{3}(0) = \frac{14-p}{3}$.
  - This is non-negative if p is in this range.
- If $14 < p < 20$, $E_2(p) = \frac{1}{3}(14 - p) + \frac{1}{3}(0) + \frac{1}{3}(0) = \frac{14-p}{3} < 0$.
- If $20 \leq p \leq 24$, $E_2(p) = \frac{1}{3}(14 - p) + \frac{1}{3}(24 - p) + \frac{1}{3}(0) = \frac{38-2p}{3} < 0$.
- If $24 < p < 30$, $E_2(p) = \frac{1}{3}(14 - p) + \frac{1}{3}(24 - p) + \frac{1}{3}(0) = \frac{38-2p}{3} < 0$.
- If $30 \leq p$, $E_2(p) = \frac{1}{3}(14 - p) + \frac{1}{3}(24 - p) + \frac{1}{3}(34 - p) = \frac{72-3p}{3} < 0$.

Adverse Selection

- The optimal choice is for Player 2 to offer $p = 10$. If $\alpha = L$, Player 1 will accept; otherwise Player 1 will reject.
- Note that in only the lowest quality case does trade occur.
- This is clearly inefficient, since trades that would benefit both parties are not taking place.
- This is an example of *adverse selection*, in which the low-quality type "drives out" the high-quality type from the market, due to uncertainty.
- One way to overcome this problem is if the buyer could get some information about the true quality of the car.
- Sometimes, a trusted third party can provide this information; if not, a costly signal could be used.

Adverse Selection in Lending (Ch. 2.3)

- based on "market for lemons", Akerlof (1970)
- Assumptions:
  - Large number of entrepreneurs with a risky project
  - Project requires fixed investment of 1
  - Gross return is random: $\tilde{R}(\theta) = 1 + \tilde{r}(\theta)$
  - Net returns $\tilde{r}(\theta)$ follows a normal distribution $N(\theta, \sigma^2)$
  - Variance σ^2 is same for all projects, θ is *private* information of the entrepreneur (but overall distribution is common knowledge)

Assumptions

- Investors are risk-neutral, have access to a storage technology (riskless, return=1)
- Entrepreneurs have initial wealth $W_0 > 1$, enough to finance project, but are risk-averse
- Utility function: $u(w) = -e^{-\rho w}$, where w is final wealth, ρ is risk aversion parameter
- If θ were publicly observable, each entrepreneur would sell project to market at price $P(\theta) = E(\tilde{r}(\theta)) = \theta$ and would be *perfectly insured*, i.e. maximizes expected utility over all states of the world
- This is due to normal distribution, exponential utility (a special case)
- Then, final wealth of an entrepreneur with type θ would be $W_0 + \theta$

Private Information

- Suppose now that θ is *private* information, investors cannot distinguish between entrepreneurs of different type.
- Price of equity P will be same for all firms.
- Suppose an entrepreneur of type θ decides to self-finance, gets expected utility:

$$Eu(W_0 + \tilde{r}(\theta)) = u(W_0 + \theta - \frac{1}{2}\rho\sigma^2)$$

- If the entrepreneur instead decided to sell the project to the market, gets certain utility

$$u(W_0 + P)$$

- Therefore, entrepreneur will only go to the financial market (sell project at price P) if

$$\theta < P + \frac{1}{2}\rho\sigma^2 = \hat{\theta}$$

Private Information

- Only entrepreneurs with a low expected return will go on the market, an *adverse selection* problem.
- High quality entrepreneurs choose not to participate.

Conditions for Efficiency of Equilibrium

- At equilibrium average return on equity will be P, since investors are risk-neutral, where
$$P = E\left[\theta | \theta < \hat{\theta}\right]$$
- In general, this equilibrium is inefficient. Efficiency is when all projects with expected return > 1 are outside financed (since all entrepreneurs seek to take on less risk)
- Assume a binomial distribution for θ: can take on two values, $\{\theta_1, \theta_2\}$ with probabilities π_1, π_2 respectively
- $\theta_1 < \theta_2$

Conditions for Efficiency of Equilibrium

- Condition for efficiency at equilibrium: all projects are outside financed, if P is high enough to induce high types to go to market

$$\theta_2 < P + \frac{1}{2}\rho\sigma^2$$

$$\rightarrow \pi_1\theta_1 + \pi_2\theta_2 + \frac{1}{2}\rho\sigma^2 \geq \theta_2$$

$$\text{or} \quad \pi_1(\theta_2 - \theta_1) \leq \frac{1}{2}\rho\sigma^2$$

- First term captures the "adverse selection" effect, second term captures risk premium

Signaling through Self-Financing

- Suppose that entrepreneurs can partially self-finance, i.e. sell a fraction $1 - \alpha$ to the market, and retain the other fraction α.
- If α is high enough, there will be a *separating equilibrium* where high types self-finance, and low types do not. This allows investors to distinguish between them, resulting in a different price of equity for each type.
- Assume that capital markets are efficient, i.e. prices are driven down to marginal cost.
- Minimum price an entrepreneur of type θ_i will sell for is θ_i.
- Expected utility without self-financing (no uncertainty):

$$u(W_0 + \theta)$$

- Expected utility, given self-financing level α:

$$Eu(W_0 + (1 - \alpha)\theta + \alpha\tilde{r}(\theta))$$

Separating Equilibrium

- "no-mimicking condition": high type θ_2 has an incentive to finance, while low type θ_1 does not

$$Eu(W_0 + (1-\alpha)\theta_2 + \alpha\tilde{r}(\theta_2)) \geq u(W_0 + \theta_1)$$

$$\rightarrow \theta_1 \geq (1-\alpha)\theta_2 + \alpha\theta_1 - \frac{1}{2}\rho\sigma^2$$

$$\rightarrow \frac{\alpha^2}{1-\alpha} \geq \frac{2(\theta_2 - \theta_1)}{\rho\sigma^2}$$

- Utility for type θ_2:

$$u(W_0 + \theta_2 - \frac{1}{2}\rho\sigma^2\alpha^2)$$

- The "informational cost of capital" in terms of lost income is

$$C = \frac{1}{2}\rho\sigma^2\alpha^2)$$

Coalitions of Borrowers

- Suppose that N entrepreneurs with *independent* projects form a partnership to diversify risk.
- Expected return is still θ_2, but variance goes down to σ^2/N.
- Holding companies can be interpreted as this type of coalition.
- Financial intermediaries who issue equity on financial markets, and invest in several subsidiaries.
- Cost of financing is lower for holding company than for individual subsidiaries.

2.4: Delegated Monitoring

- When there is asymmetric information, then efficiency can be increased with *monitoring*, which can mean:
  - *screening* of projects before deciding to lend to them
  - *preventing* opportunistic behavior of a borrower (e.g. replacing management who are not performing well)
  - *punishing* borrowers who fail to meet their contractual obligations
- Specialized firms are likely to be more efficient at monitoring than individual lenders. This provides a clear justification for the role of financial intermediaries.

Delegated Monitoring

- This is based on the paper: Diamond (1980), "Financial Intermediation and Delegated Monitoring"
- There are n identical, risk-neutral firms that are seeking to finance a project.
- Assume the riskless interest rate is R.
- Each firm requires an investment of 1, and the cash flow of each firm is an i.i.d. random variable $\tilde{y}$.
- All agents agree on the distribution of $\tilde{y}$, but it is only observed by the entrepreneur of the firm, but not the lender.
- Assume $\tilde{y} > 0$, and $E(\tilde{y}) > R + K$, where $K > 0$ will be defined later.
- The entrepreneur can lie and misreport the cash flow of the firm.
- How can the lenders and borrowers come to an agreement?

Approach 1: Optimal Financial Contract

- Let's try to come up with a contract that is incentive-compatible (both sides will make a positive expected payoff by agreeing to it).
- A *complete contract* is a rule that specifies what each party should do, for each observable state of the world.
- Here, only the entrepreneur's chosen repayment z is observable, so a *contract* specifies the actions of the borrower and lender for every possible z.
- In the absence of outside enforcement, a contract is only useful if both sides voluntarily agree to follow its terms.
- Therefore, any contract that is actually agreed to must be a Nash equilibrium: the parties have no incentive to deviate from the terms of the contract.

Approach 1: Optimal Financial Contract

- Suppose y is the actual cash flow of the firm.
- $z(y)$ is a function that specifies what the entrepreneur will repay, given y.
- $\phi(z)$ is the *penalty* that is imposed by the lender when the entrepreneur repays z.
- An optimal penalty function must satisfy these conditions:
  - Penalty must be high enough to deter underpayment
  - Penalty must be small to avoid welfare costs

Approach 1: Optimal Financial Contract

- Consider this penalty function: $\phi^*(z) = \max(h - z(y), 0)$, where h is the contractually agreed level of repayment
- The sum of repayment and penalties is always h; therefore, the entrepreneur is indifferent between lying and telling the truth
- We'll assume that the entrepreneur will not lie in this situation.

Approach 1: Optimal Financial Contract

- What should h be? Consider this value of h: the lowest value that provides lenders with an expected return of R.
- h is the smallest value that satisfies

$$P(\tilde{y} < h)E\left[\tilde{y}|\tilde{y} < h\right] + P(\tilde{y} \geq h)h = R$$

- Consider $z(y) = \min(h, y)$.
- The entrepreneur passes on all the cash flow if $y < h$; otherwise, he repays h and keeps the rest for himself
- This is like a standard credit contract: if the borrower cannot repay, the lenders seize the firm and liquidate the assets
- This contract is incentive-compatible for both the lender and the borrower:
  - the lender's expected return is equal to R, by the above equation
  - the borrower is indifferent between lying and not lying, as shown previously, so will report the true y

Approach 1: Optimal Financial Contract

- The final specification of the contract is:
  - The borrower agrees to repay h, which satisfies

$$P(\tilde{y} < h)E\left[\tilde{y}|\tilde{y} < h\right] + P(\tilde{y} \geq h)h = R$$

  - If he repays some amount $z < h$, then the lender will impose a penalty of $h - z$, otherwise the penalty is zero
- This is not socially efficient, since the entrepreneur has to pay a penalty even when he is telling the truth.
- Entrepreneurs could be made better off without making lenders worse off, if $\tilde{y}$ were *observable*.
- An alternative solution: Monitoring by lenders

Approach 2: Contract with Monitoring

- Suppose there are m lenders per firm, and that each lender can spend $K > 0$ to observe $\tilde{y}$.
- Welfare is increased if $mK < E\left[\phi^*(z(y))\right]$, i.e. if the total cost of monitoring is less than the expected amount of penalty.
- Monitoring is preferable if m is small, and if the expected penalty is high (e.g. if there is a high probability of low returns)

Approach 3: Delegated Monitoring

- If monitoring is delegated to a financial intermediary (FI), monitoring costs can be reduced to K
- However, this brings up an additional problem: how can the lenders trust the FI? There must be an additional level of monitoring
- We can combine the two previous approaches: the lenders have an optimal contract with penalties between themselves and the FI
- And, the FI monitors the borrowers.
- If the FI deals with a large number of firms with independent returns, then the probability of low returns goes to 0, by the Law of Large Numbers
- Then, the expected penalties go to zero as well

Next Week

- For next week, please read the Diamond (1984) paper (I will put it on the web site), and Ch. 3.1-3.2 in the textbook.